Space Weather Technical Forecast

Issued on Friday, 12 May 2023 at 14:42 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1-G2 Minor/Moderate geomagnetic storm conditions expected on 12 and 13 May, with a chance of G3/Strong storms due to the CME arrival. S1/Minor Solar Radiation Storm easing. R1/R2 Minor/Moderate radio blackouts expected.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the last 24 hours, with a short duration flare originating from AR3294 peaking at M1.9 at 11/1829UTC. It was quickly followed by a CME which has been analysed as not Earth-directed. However confidence is low, due to limited satellite imagery at that time. There are currently nine sunspot regions on the visible disc, one of which is recent and has not been numbered yet. AR3296 is now approaching the western limb and becomes increasingly difficult to analyse. AR3297 has undergone a marked decline and has lost a few spots, along with significant visual complexity. AR3301 and AR3302 have become slightly more complex but remain stable. AR3304 has significantly decreased in size and complexity. The new region in the northeast quadrant is relatively simple but developing quickly, with the addition of several basic spots.. Aside from the CME mentioned, no further Earth-directed CMEs have been identified on available imagery.

Solar Wind / Geomagnetic Activity: The solar wind parameters are indicative of a CME arrival. The solar wind speed at L1, was following a declining trend at the beginning of the period but suddenly increased by 100km/s at 12/0547UTC to reach 550-580km/s. It is now slowly declining, currently around 520km/s, however density similarly increased from 8ppcc to 13-16ppcc at 12/0547UTC, while the total magnetic field strength increased from 6nT to 12nT. The north-south component (Bz) was weak but became erratic around the same time, varying from 6nT to +12nT. It was however predominantly positive, resulting in a rather muted response from the geomagnetic activity which remained Quiet to Unsettled.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as measured at GOES16, consistently declined over the past 24 hours whilst remaining below the S1 threshold. High energy electron flux (greater than 2MeV), as measured at GOES16, has varied between background and moderate levels on a diurnal trend. The 24-hour integrated fluence has been well below Active levels, but with a slightly increasing trend. At 12/0000UTC 1.52e7 integrated pfu was recorded.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is currently close to background levels but is expected to become increasingly Moderate over the next four days. The risk is not negligible initially but is expected to gradually transfer east and come from other regions, such as AR3301 and AR3302, which are growing in size and complexity.

Solar Wind / Geomagnetic Activity: A full halo CME which left the Sun late on 09 May has arrived at Earth early this morning (12 May). The associated magnetic field is currently

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unfavourable to the development of any significant geomagnetic activity but its effects are expected to increase through the day and into 13 May, with a risk of G1 or G2 (Minor or Moderate) storms and even a chance of G3 (Strong) storm intervals. The effects of the CME are expected to subside at the end of day 2 (13 May), the 14 and 15 May remaining largely Quiet with odd Unsettled period.

Energetic Particles / Solar Radiation: The risk of seeing the high energy (greater than 10 MeV) proton flux above the S1 threshold is considered possible today and tomorrow (12 and 13 May) but is expected to decline over time. High energy (greater than 2MeV) electron flux is expected to persist at normal background to moderate levels. The associated 24-hour fluence is forecast to persist below the Active threshold.

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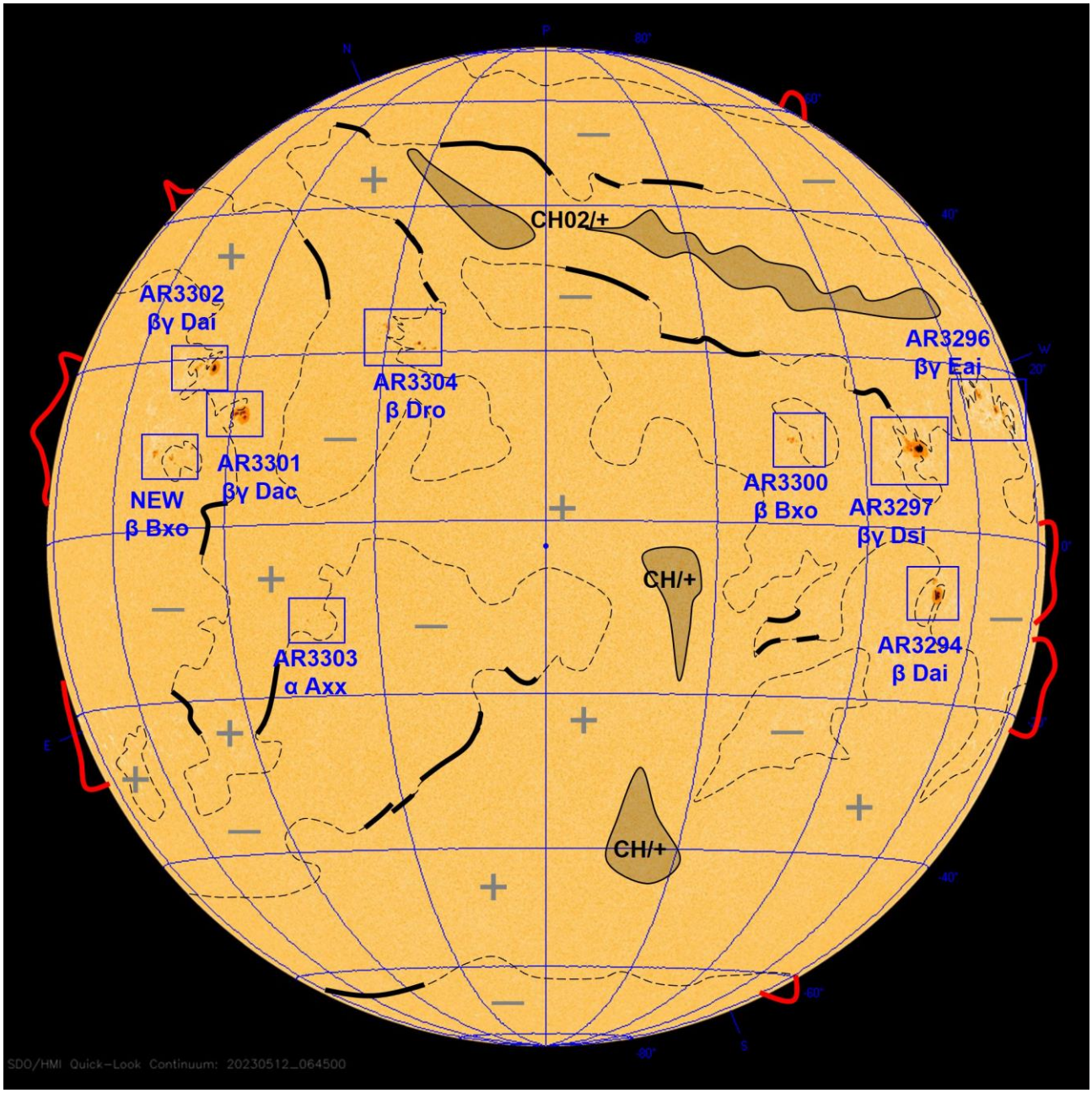
Figure 1. Solar Analysis Valid *12/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:
A full halo CME which left the Sun late on 09 May has arrived at Earth early this morning (12 May). The associated magnetic field is currently unfavourable to the development of any significant geomagnetic activity but its effects are expected to increase through the day and into 13 May. A further CME was observed shortly after 1829UTC on the 11 May, originating from AR3294. This CME has been analysed as not Earth-directed. However confidence is low, due to limited satellite imagery at that time.

Aside from these, a faint CME was observed leaving the sun in the early hours of the 12th whilst propagating rapidly towards the southeast. The source is currently unknown, due to a gap in the satellite imagery feed. A filament was also seen lifting off the southwestern quadrant later but seems to have been reabsorbed into the corona since.

Geomagnetic activity is forecast to become increasingly Active over the next 24 hours, with a risk of G1 or G2 (Minor or Moderate) storms and even a chance of G3 (Strong) storm intervals. The effects of the CME are expected to subside at the end of day 2 (13 May), the 14 and 15 May remaining largely Quiet with odd Unsettled period.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	90	80	20	10
Strong	G3	No	50	30	5	1
Severe	G4	No	15	10	1	1
Extreme	G5	No	1	1	1	1

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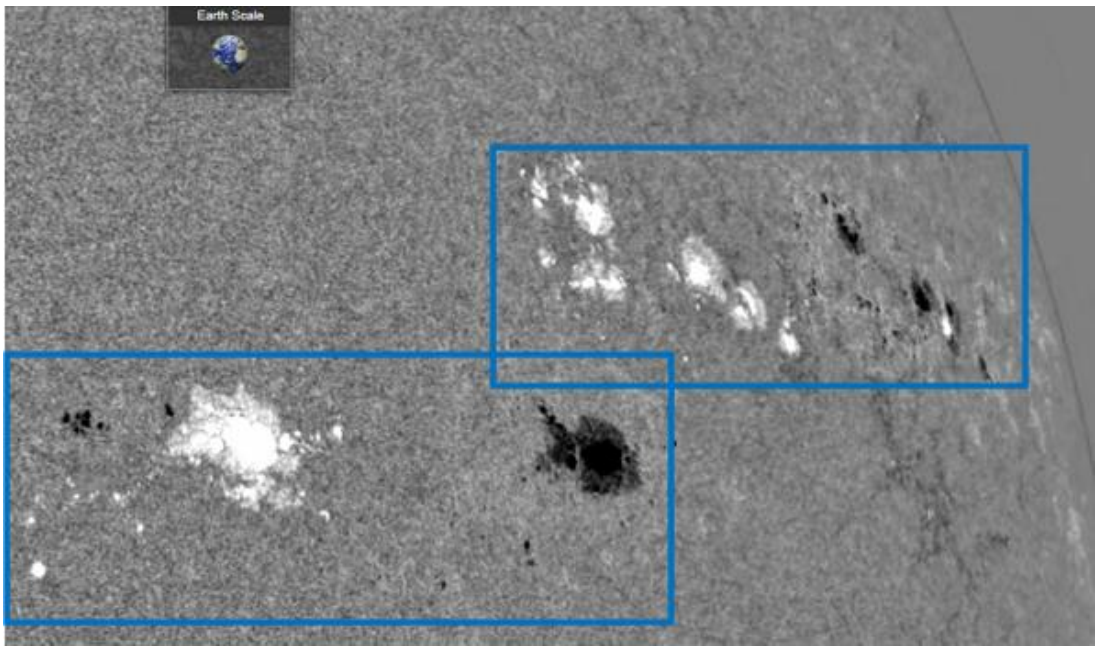
Radio Blackouts - X-Ray Flares:
There are nine sunspot regions on the visible disc, one of which is recent and has not been numbered yet. AR3296 is now approaching the western limb and becomes increasingly difficult to analyse. AR3297 has undergone a marked decline and has lost a few spots, along with significant visual complexity. AR3301 and AR3302 have become slightly more complex but remain stable. AR3304 has significantly decreased in size and complexity. The new region in the northeast quadrant is relatively simple but developing quickly, with the addition of several basic spots.

Solar activity is currently close to background levels but is expected to become increasingly Moderate over the next four days. While the region (AR3294) responsible for the M1.9 flare that was observed at 11/1829UTC is still potentially capable of generating further M-class flares, it is slowly decaying whilst becoming more stable, similarly to what is happening with AR3296 and AR3297. The risk is not negligible initially but is expected to increase whilst transferring to the eastern regions, such as AR3301 and AR3302, which are growing in size and complexity.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	30	40	50	60
Very Active	R3 to R5 X Class	No	5	10	15	20

Figure 2: 24-hour growth trends of AR3296 & AR3297, as shown in HMIIF footprint difference imagery generated using Helioveiwer.org. Sunspot footprints as of 11/1200UTC are shown in white, whereas their appearance 24 hours later is shown in black. Both regions are showing a degree of simplication, with smaller and fewer spots.



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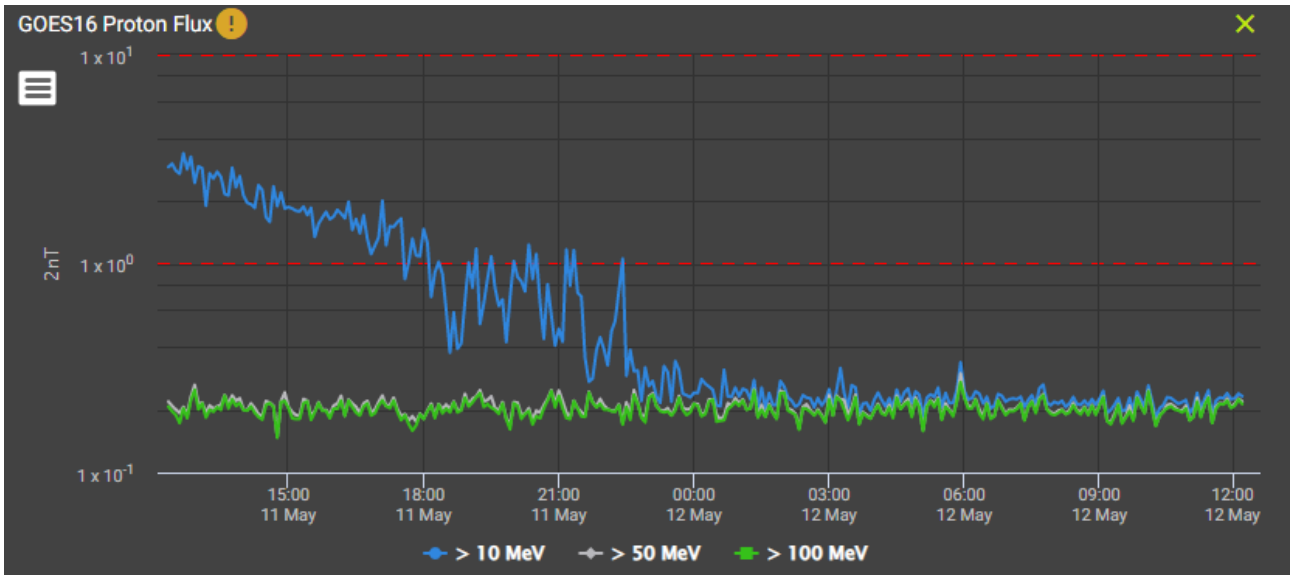
Solar Radiation Storms - (High Energy Protons):
The high energy (greater than 10MeV) proton flux, as observed by GOES16 is now below the S1/Minor Storm threshold. The recent M1.9 flare that was observed at 11/1829UTC from AR3294 has not had any impact on the proton counts and now that this region (and the surrounding regions) appear to be stable or slightly decaying, the risk is considered to be possible today and tomorrow (12 & 13 May) but declining over time.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	40	30	20	10
Very Active	**≥ S3 ***	No	5	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 3: GOES 16 Proton Flux declining down to background levels



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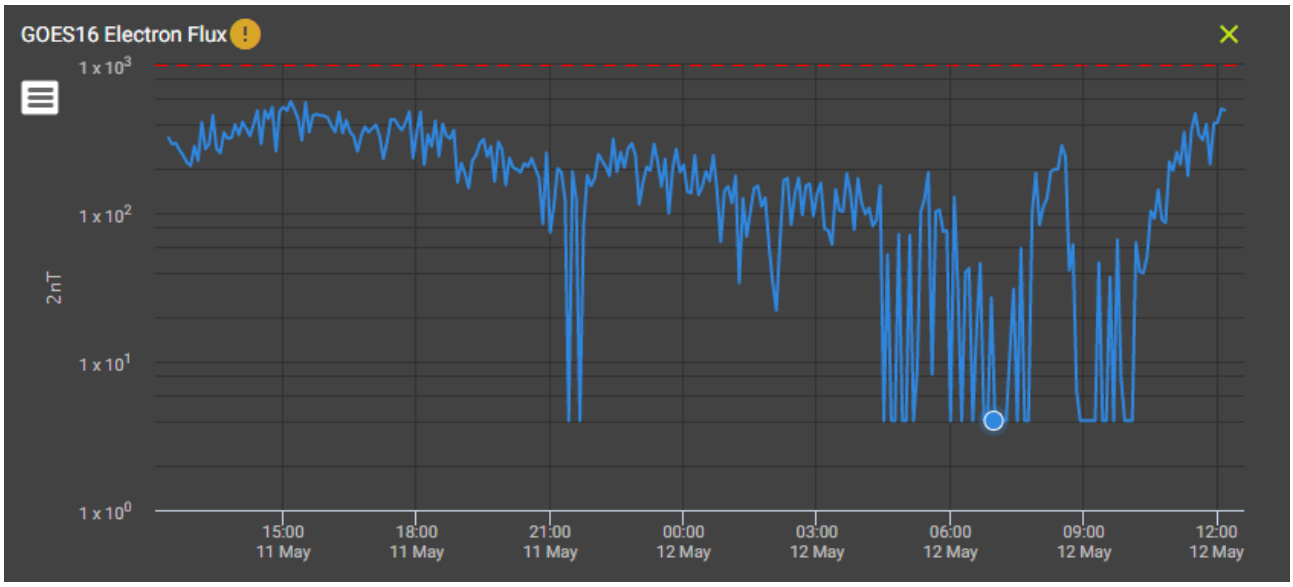
High Energy Electrons Event (≥ 2MeV):
The high energy electron flux (greater than 2MeV) is expected to remain below the high level through much of the period, due to a combination of significant geomagnetic activity redistributing elections away from GEO orbits and also increased solar wind speeds distorting the electron belts away from GEO. The British Antarctic Survey Radiation belt Model (BAS-RBM) is suggesting that the anticipated CME could feed electrons into lower Earth orbits, where they could be contained until any CME effects and solar wind speeds ease later in the period. This would allow the belts to relax back towards their natural orbits.

Electron fluence values are on a slight increasing trend due to the recent CME effects and fast solar wind, but appear to have reached a plateau. Values are expected to remain below the Active (1e8 integrated pfu) level throughout, but with decreasing confidence towards the end of the period, as the effects of forecast CME arrivals and solar wind speeds subside.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	10	20	30	40
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	5	10

Figure 4: GOES 16 Electron Flux oscillating between background and moderate levels.



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